PRS: Physics Reconstruction and Selection
HCAL/JetsMET group

JetsMET - Overview

Shuichi Kunori
U. of Maryland
26-Sep-2001

HCAL/JetsMET Group

S.Eno / S.Kunori - Coordinator

http://home.fnal.gov/~sceno/jpg/Default.htm

Dates:

End 2002 DAQ TDR (end 2001 for HLT section)
End 2004 Physics TDR

Organization:

- HCAL simulation – Sunanda Banerjee (TIFR)
  - CMSIM/OSCAR(Full/Fast)
  - Verify shower model in G4.
- Calibration & Monitoring – Olga Kodolova (MSU)
  - energy scale of jets, MET, tau
  - -> from detector construction/commission to in-situ calibration.
- HCAL in ORCA – Salavat Abdullin (Maryland)
  - readout simulation + …
- Physics objects with HCAL – Sasha Niketenko (CERN/ITEP)
  - jets, MET & tau

Activities present and near future

past
present
future

Simulation

- Geometry in CMSIM/OSCAR.
- Verify CMSIM/OSCAR.
- Verify hadron shower physics in G4.

Calibration & Monitoring

- Data definition for Calibration Database
- HF (HB/HE) Calibration scenario
- In-situ calibration
  - γ/Z0-jet balancing // M(jj) for W from top
- Improvement of energy scale (+ resolution) [20GeV-TeV]

ORCA code

- Readout simulation / Jet finder / MET code / ntuple maker

HLT (τ jet, jets, MET)

- L1 verification / HLT algorithm and rates / Trigger table

Physics Analysis

- Dijet / Single top / ttH / qqH, H→ $\tau\tau$, WW, invisible / SUSY / …

Calibration- General Plan

Following procedure described in HCAL TDR. (sk's talk on 26-Sep-2000)

- http://home.fnal.gov/~kunori/cms/meetings/000926-cmsweek/shuichi/hcal-calib-0009.pdf

Three (+) Tasks

- HCAL Calibration
- Synchronization
- Monitoring on those through life of exp.

\+ Jet/MET energy scale

Calibration & Monitoring Group in HCAL/JetMET group

- Group leader- Olga Kodolova

Data Flow

>>> front end <<<

Scint. Lights
->Tile->Fiber1&2->OptCable
->HPD->Amp->ADC
Charge (for 5-10xings)
HTR (ch) ->(L1Path)
->(DAQPath)

>>> L1Path <<<

E_T(L1Primitive: 8bits:non-linear)
->L1 LUT (ch)
E_T(4x4 HcTower: 8bits:linear)
->L1Calo
E_T(L1jets),Et(L1tau),Et(L1MET)
->L1CaloGlobal(Threshold (obj))
->L1Global
L1Trigger

>>> after DAQPath <<<

->ReadoutAnalyzer (ch)
E_T(channel)
->TowerCreator
E_T(Ec+Hc Tower)
->Jet/MET/tauReco
E_T(jetR),Et(tauR),Et(METR)
->EtCaloCorrection (obj)
(corr. for linearlity)
E_T(JetC),Et(tauC),Et(METC)
->EtPhysCorrection (obj)
(corr. for out-of-cone)
E_T(Parton)

Calibration/correction
(ch) - channel by channel
(obj) - phys. Obj, (jet, tau, MET)

Calibration - Tools

A) Megatile scanner:

- Co^{60} gamma source
- each tile: light yield
- during construction
  - all tiles

B) Moving radio active source:

- Co^{60} gamma source
- full chain: gain
- during CMS-open (manual)
  - all tiles
- during off beam time (remote)
  - tiles in layer 0 & 9

C) UV Laser:

- full chain: timing, gain-change
- during off beam time
  - tiles in layer 0 & 9
  - all RBX

D) Blue LED:

- timing, gain change
- during the off beam time
  - all RBX

E) Test beam

- normalization between
  - GeV vs. ADC vs. A,B,C,D
- ratios: elec/pion, muon/pion
- pulse shape/time structure
- before assembly
  - a few wedges

F) Physics events

- mip signal, link to HO
  - muon
- calo energy scale (e/pi)
  - charged hadron
- physics energy scale
  - photon+jet balancing
  - Z+jet balancing
  - di-jets balancing
  - di-jet mass
    - W->jj in top decay

>> non-linear response

>> pile-up effect

Calibration & Monitoring Scenario (HB/HE)

(same to HF)

1) Before megatile insertion
- megatile scanner: all tiles
- moving wire source: all tiles

2.1) After megatile insertion
- moving wire source: all tiles / 2 layer
- UV laser: 2 layers/wedge

2.2) After megatile insertion
- test beam: a few wedges.

→ Absolute calib. Accuracy of 2% for single particle

3) Before closing the CMS
- moving wire source: all tiles
- UV laser & blue LED: all RBX

(do 3, about once/year)

4) Beam off times
- moving wire source: 2layer/wedge
- UV laser: 2 layer/wedge
- UV laser & blue LED: all RBX

→ Monitor for change with time Accuracy < 1%

once/year

a few times/day (?)

5) Beam on (in situ)
- jets / tau / MET ECAL+HCAL

JetMET C & M Organization (O.Kodolova)

SK's first guess

Task	Names
Test Beam and initial energy scale • Requirement for beam test / analysis / source	A.Gribushin H.Budd (HE) (HO)
Response equalization (Uniformity + Dead Ch.) • Source/min-bias events	A.Krokhotine K.Teplov ???
Time Dependence • Source/min-bias/laser/LED	A.Yershov (HB) (HE) (HO)
Data collection and maintenance • Data type / Data format / file system / database	A.Oulianov T.Kramer
Software Tools • ORCA Interface	A.Oulianov S.Abdullin
JetMET energy scale • MC study / In-situ calibration	I.Vardanyan A.Kokhotine P.Hidas V.Konnopianikov …
Synchronization	???

Calibration
Relation to Other Groups

JetMET C & M group

- TB & init. scale
- Equalization
- Time dependence
- :
- :

Data collection & maintenance

request

data

Test Beam
HB/HE/HO/HF

Control
Source calibration
Laser/LED

- Optical System HB / HE / HO / HF
- Photodetectors
- Frontend elec.
- Assembly & Test

ECAL | TRACK

Calibration
Short Term Plan

26-Sep-01 (Wed) 11:00-12:30

- A.Oulianov – Proposition on HCAL database
- T.Kramer – HCAL calibration web page
- P.deBarbaro – Data from bld 186

CPT Week (5-9. Nov'01)

- Decision on organization and more planning
- Discussion on
  - Requirements for Test Beam
  - Define data type / repository

CMS Week (5 Dec'01)

- Continuation of discussion

CMS Week (Mar'02)

→ Decision on above

HLT
τ-jets /Jets / MET

τ-jets

$\tau^+ \to \pi^+\nu$	12.5%
$\tau^+ \to \rho^+\nu \to \pi^+\pi^0\nu$	26%
$\tau^+ \to a_1\nu \to \pi^+\pi^0\pi^0\nu$	7.5%

Narrow jet (similar to electron)

BG: QCD jets

→ Refine narrowness — L2: ECAL full segmentation

→ Identify 1/3 charged tracks — L3: Pixel

Jets

BG: QCD jets

Fake (+ additional) jets due to pile-up (E_T<50GeV)

→ Improve energy scale and resolution

→ Remove fakes

MET

BG: badly measured QCD jets (+ hot/dead cell)

b/c semi-leptonic decays (?)

→ Improve energy scale and resolution

→ remove BG's.

τ jets

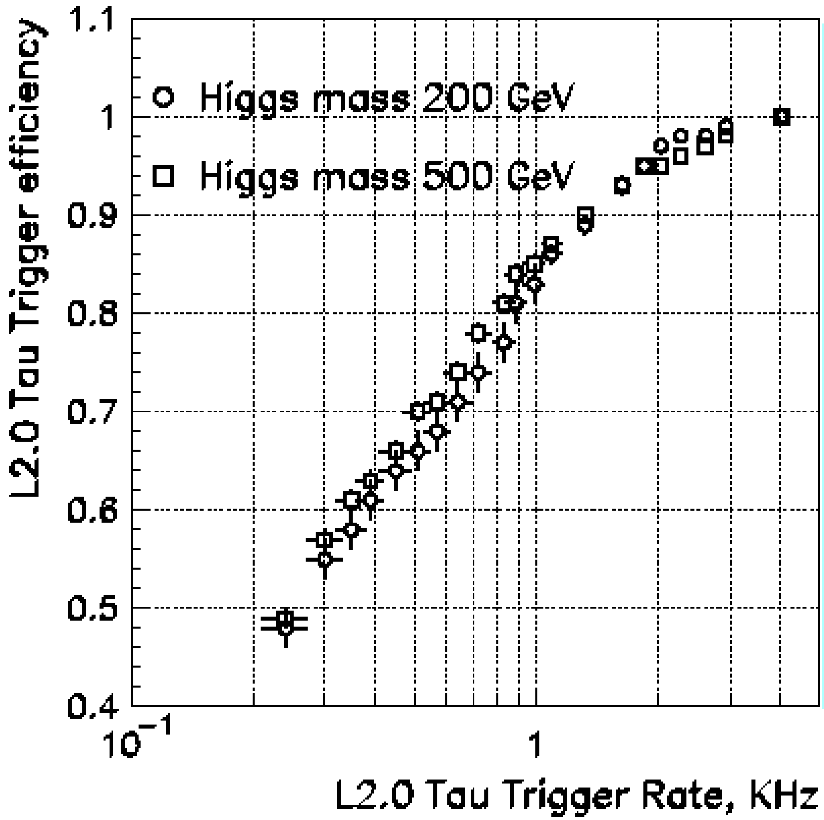
tau jet:
narrow (one prong) jet

L1/L2:
use only calorimeter
L1: 0.087x0.087
L2: individual crystal

L2.0 Tau trigger

1. reconstruct a Jet*
2. calculate e.m. isolation :
   $P_{isol} = E_t^{ecal}(R < 0.4) - E_t^{ecal}(R < 0.13)$
3. accept event if $P_{isol} < P_{cut}$

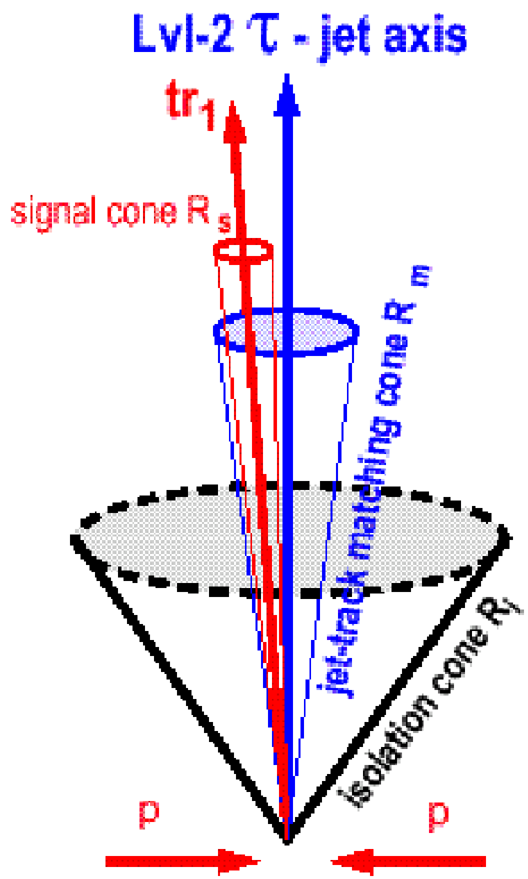
gg->bbA, A->2τ->h⁺ + h⁻ + X

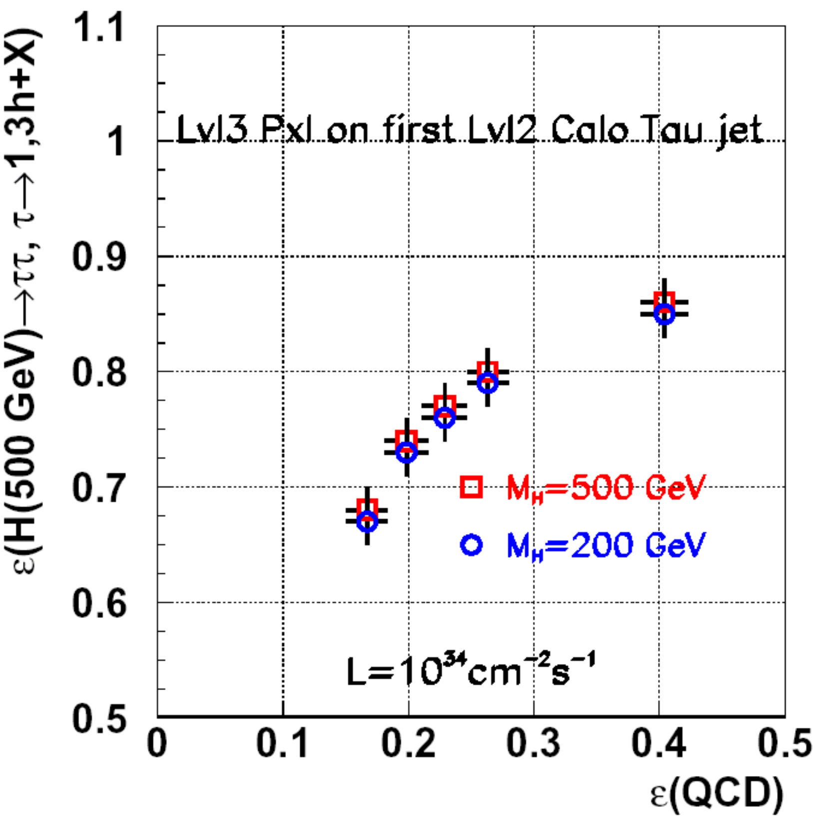


(CMS Note 2000/055)

tau jets at L3

1. Reconstruct track with pixel. (PT>1GeV)
2. Reconstruct primary vertex.
3. Track match (highest PT) to L2 tau jet
4. Track isolation





(CMS Note 2001/017)

HLT Jets and Energy Corrections

Two steps for HLT jets

1) Find jets with R=0.5 –1.0 with fixed calorimeter weights.
2) Correct energy scale to sharpen turn on curve.

Energy Correction

- **Jet based**
  1) E = a x (EC+HC), a depends on jet(ET,η)
  2) E = a x EC + b x HC, a, b depend on jet(ET,η)
- **Particle based**
  1) E = em + had (requires to separate em/had clusters) (#)
     em = a x EC for e/γ
     had = b x EC + c x HC, for had. b (c) depend on EC (HC)
- **Use of reconstructed tracks**
  1) E = E_0 + (Tracks swept away by 4T field) (#)
  2) E = EC(e/γ+neutral) + HC(neutral) + Tracks (#)

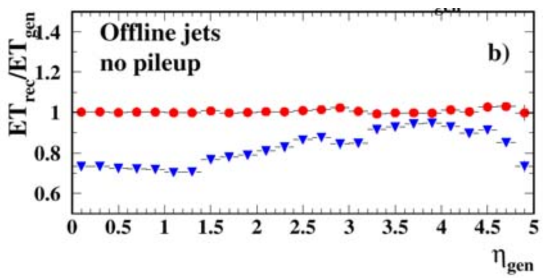
(#) Reports during the cms week.

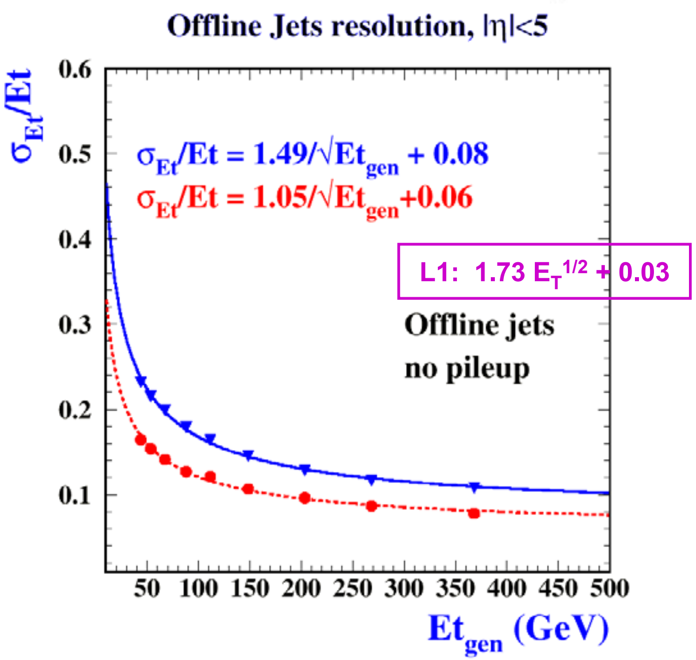
Jet Response and Correction #1

Et-eta dependent correction for QCD jets

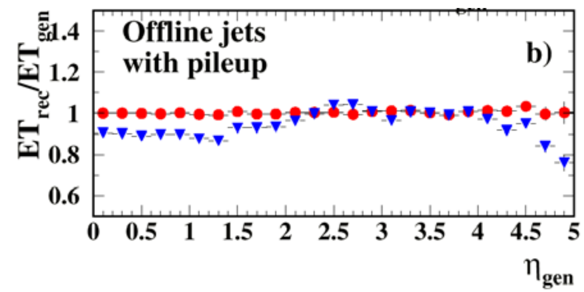
$Et(corr) = a + b \times E_T(rec) + c \times E_T(rec)^2$

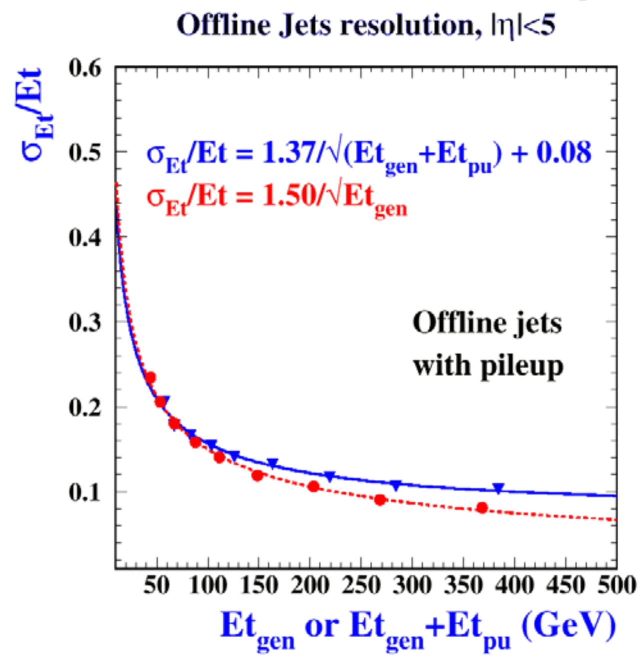
No pileup





With pileup





Dijet Mass Resolution

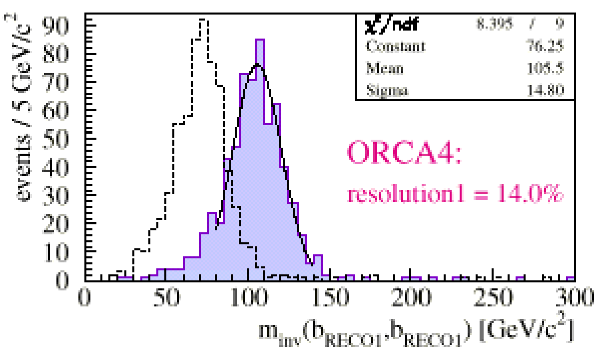
No pileup

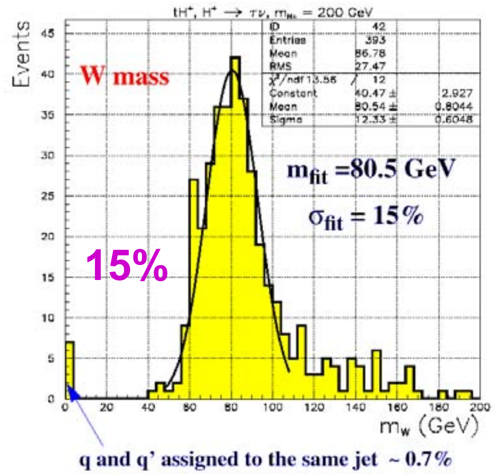
With pileup

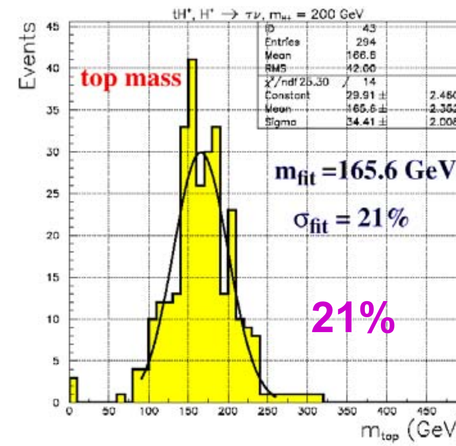
W(jj) **Top(jjj)**

Before correction

M(bb) in WH







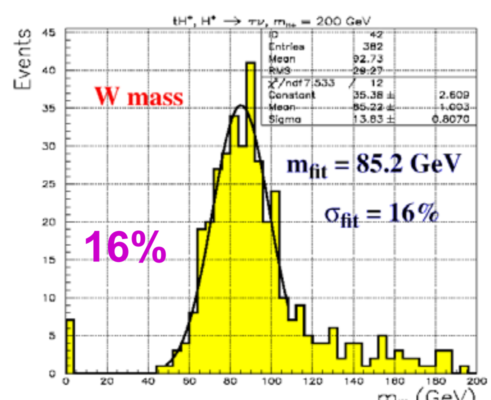
After correction

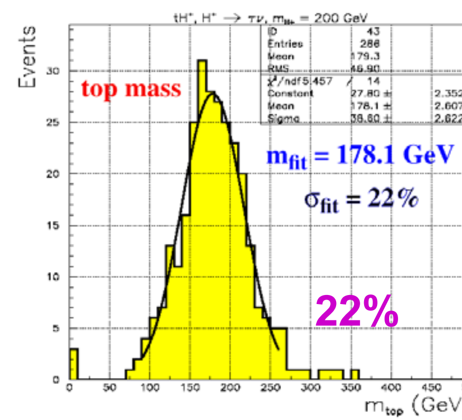
Jet energy correction

without: 19%

with: 14%

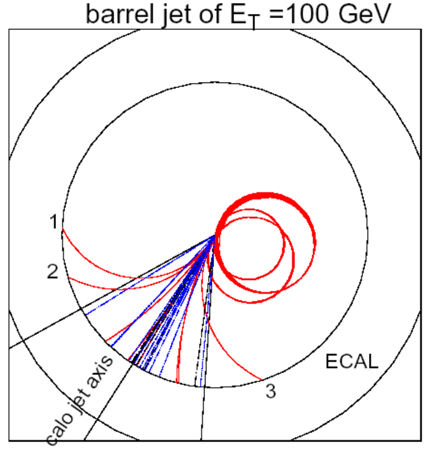
CMSJET 15%



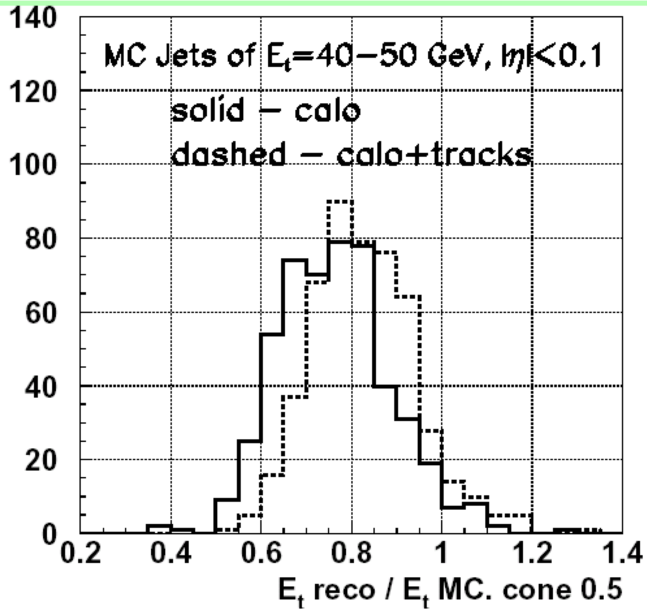


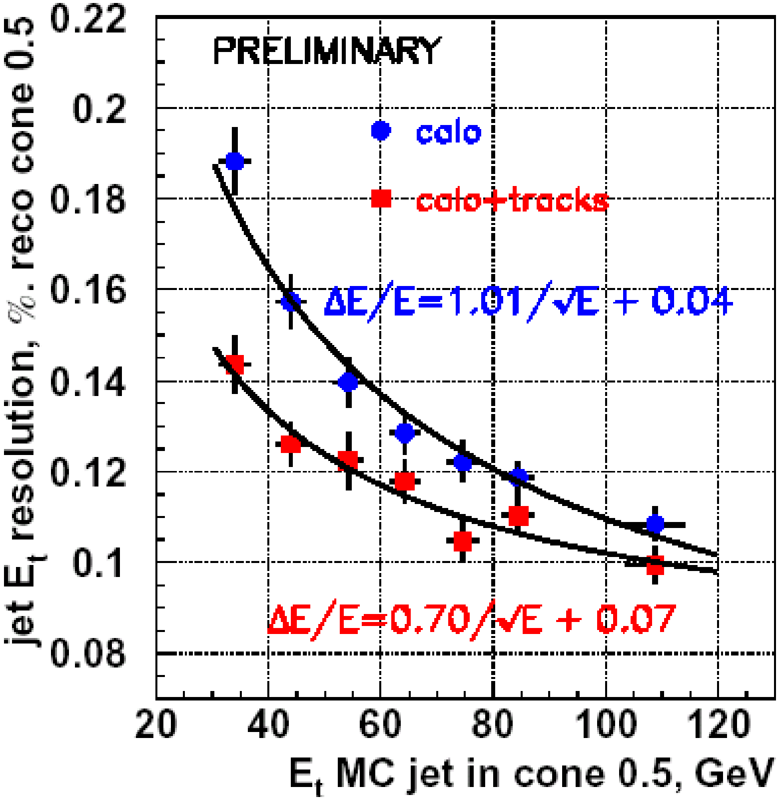
(V.Drollinger) (R.Kinunnen)

$$E_{T\,jet} = E_{T\,jet}^{calo} + p_T^{trks},$$

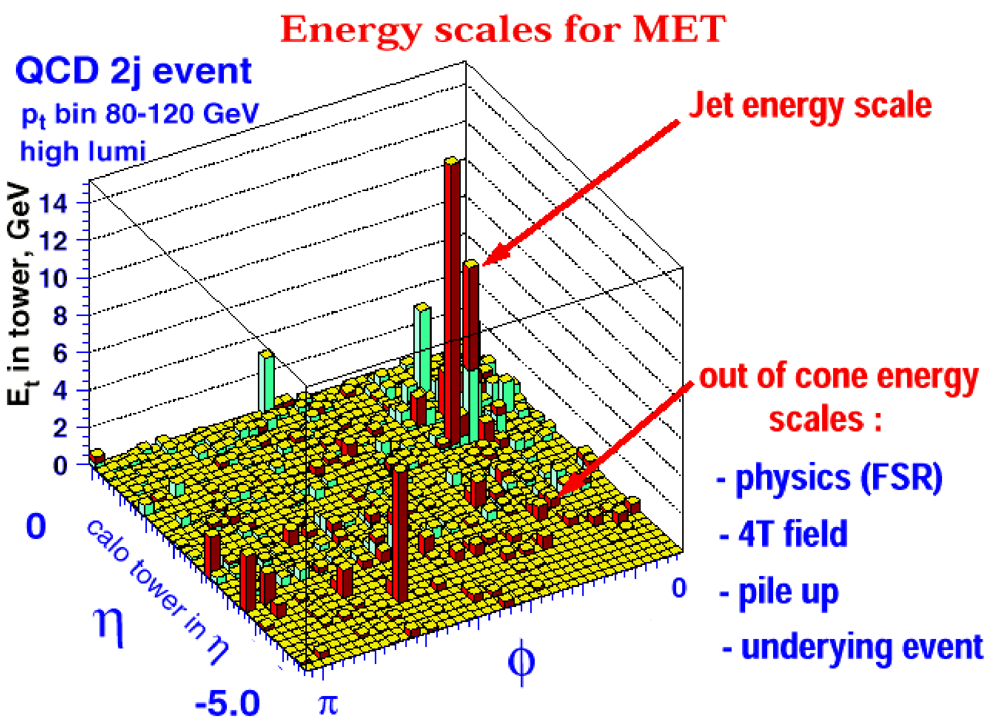


A.Nikitenko
(Talk on Wednesday)

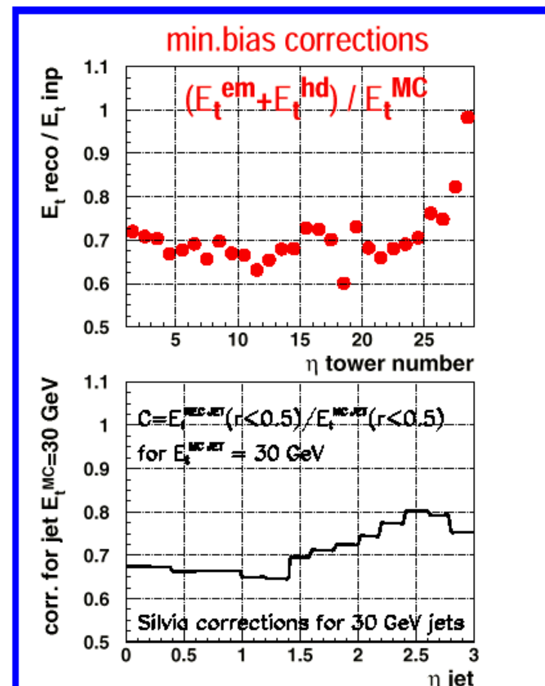




MET



Out of cone corr. uses weights for jet(30GeV) corr.



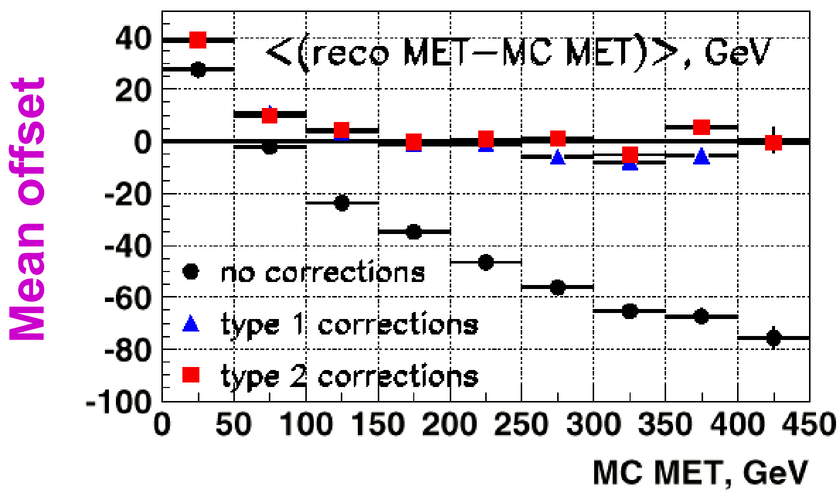
Corrections

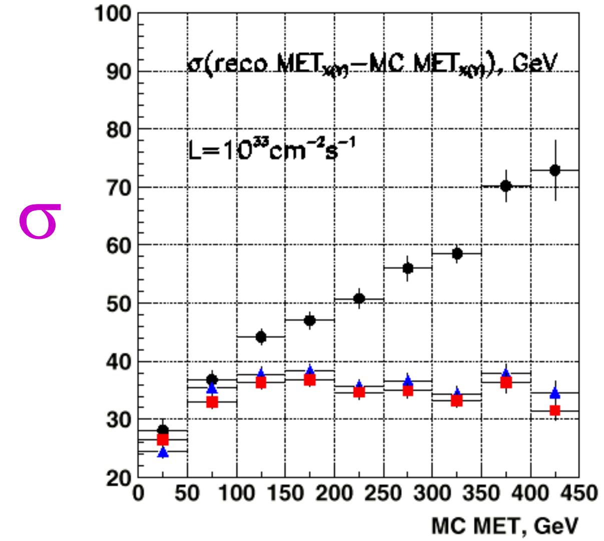
Type 1: Jet corr.

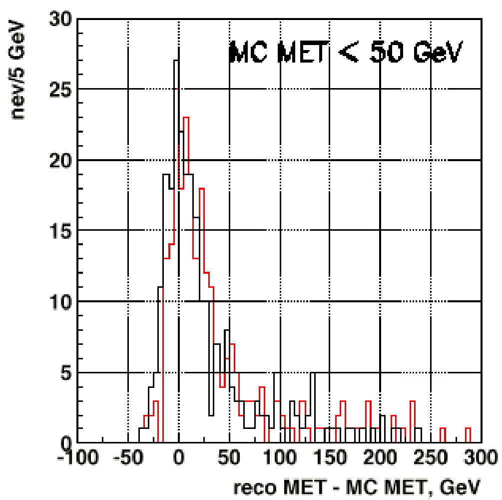
Type 2: Jet corr. + out of cone corr.

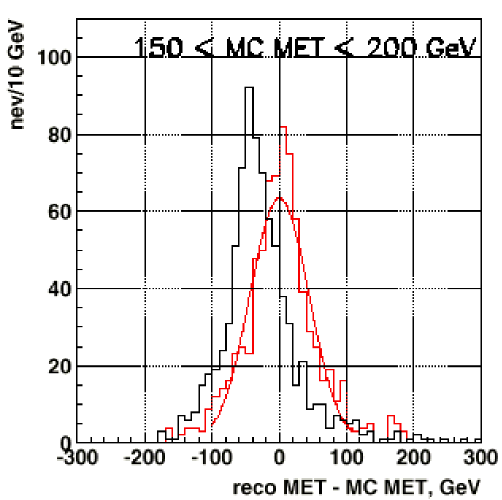
(Nikitenko)

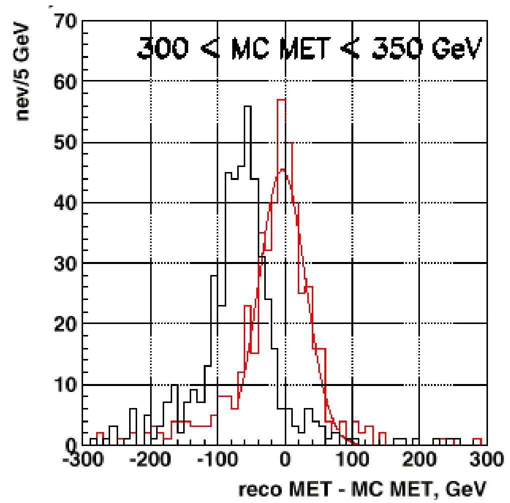
Corrected MET for mSUGURA
Jets+MET at low lumi







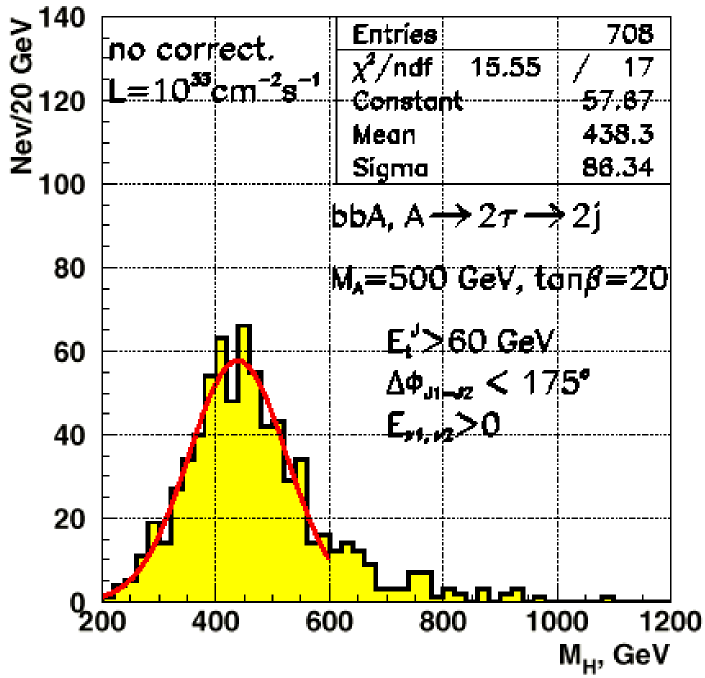




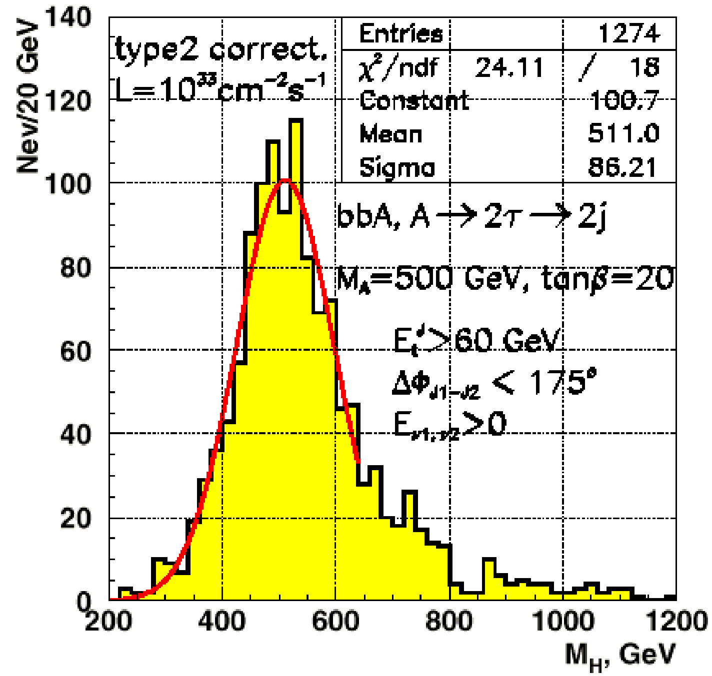
Higgs mass in bbA, A→2τ→2j

(A.Nikitenko)

before correction



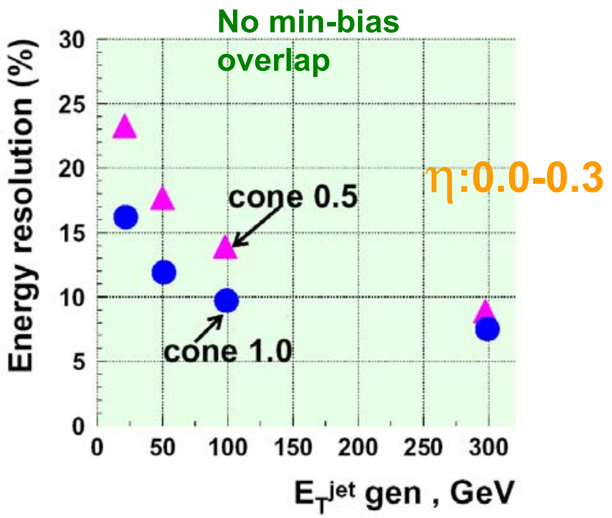
after correction

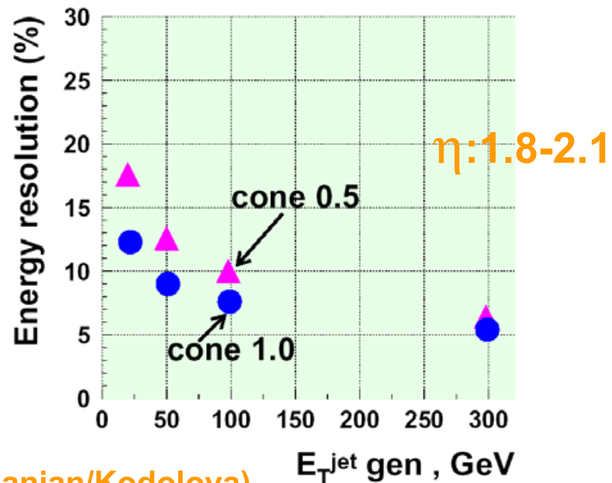


bbA, A->2τ->2j	no corrections	type1 corrections	type2 corrections	CMSJET
$<M_H>$	438.3 GeV	500.3 GeV	511.0 GeV	500.0 GeV
$\sigma / <M_H>$	19.7 %	18.9 %	16.8 %	13.4 %
ε_{reco} (corr.) / (no corr)	1	1.53	1.80	

Jet Cone Size

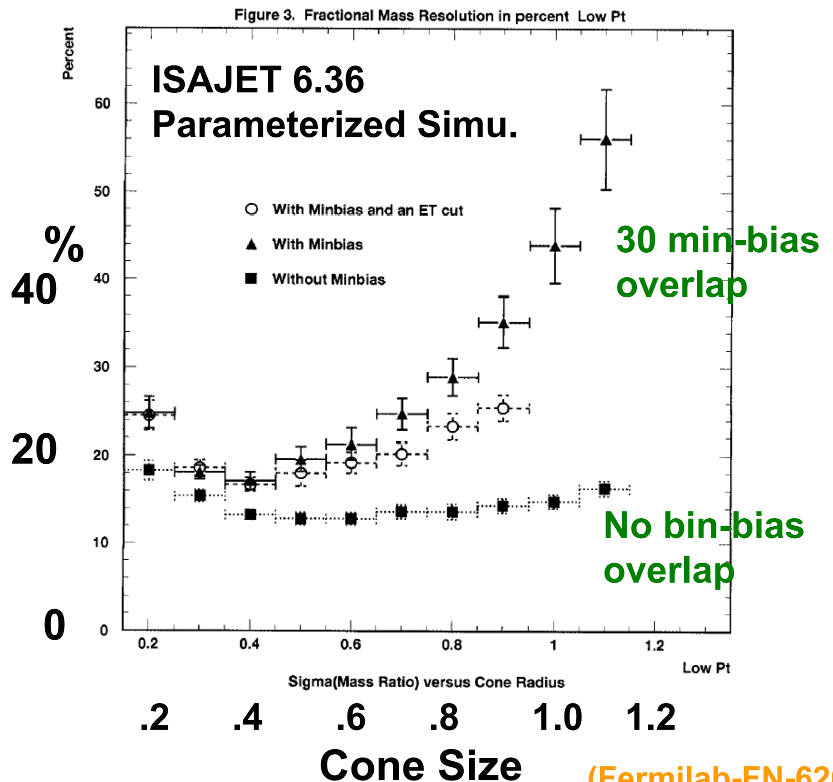
particle-jets vs. reco-jets





(Vardanian/Kodolova)

Resolution of Mass(Z→jj)
- 1994 study -

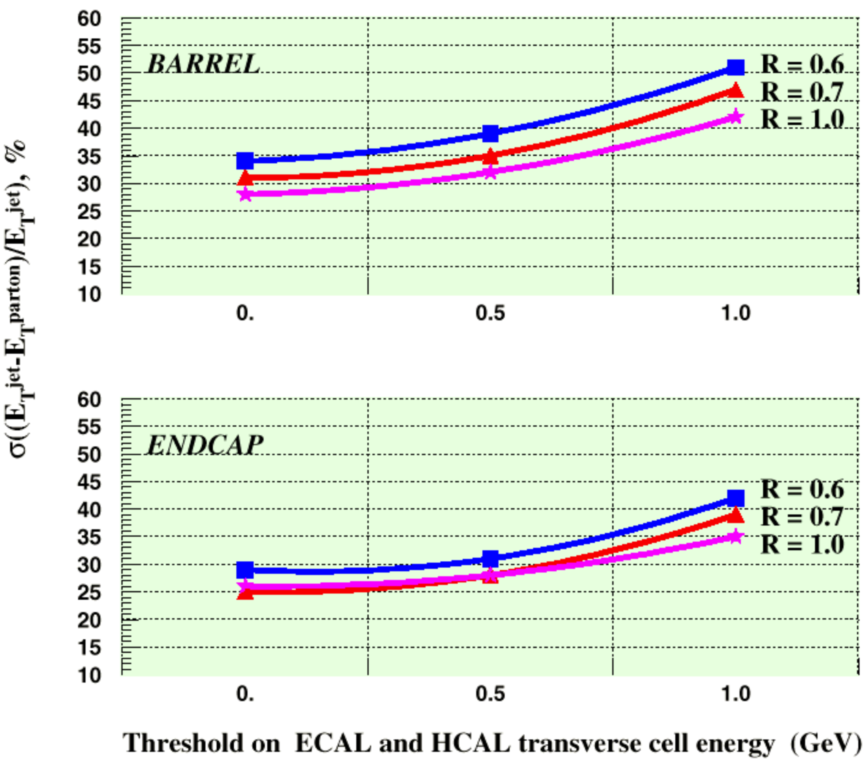


(Fermilab-FN-626)

Larger R is better for di-jets @ low luminosity.
→ Need to test with multi jets.
→ @ high luminosity

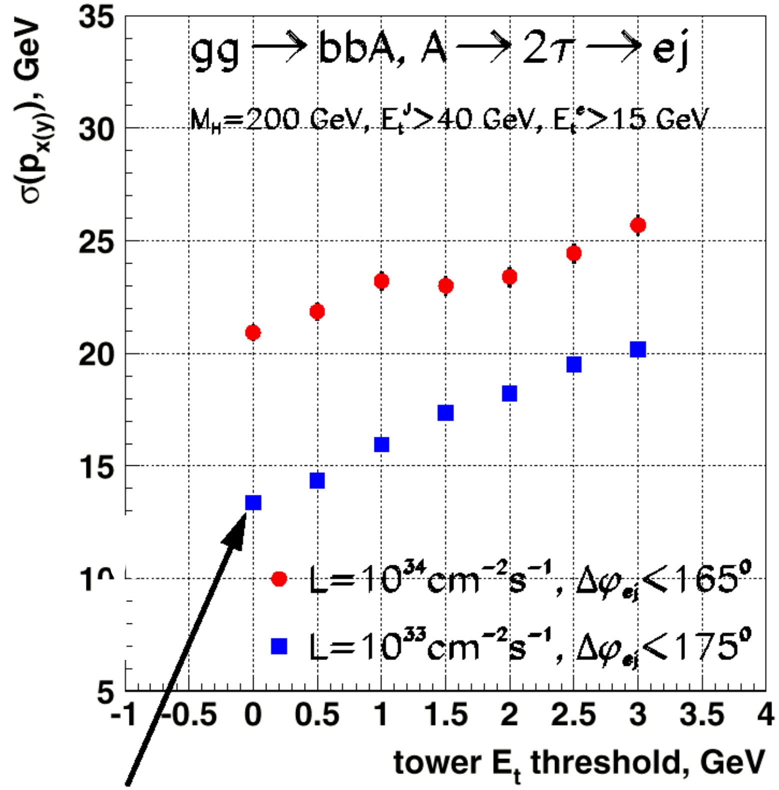
Effect of Threshold on low E_T jet and MET

20GeV parton jet @ 10E34



(I.Vardanian)

MET



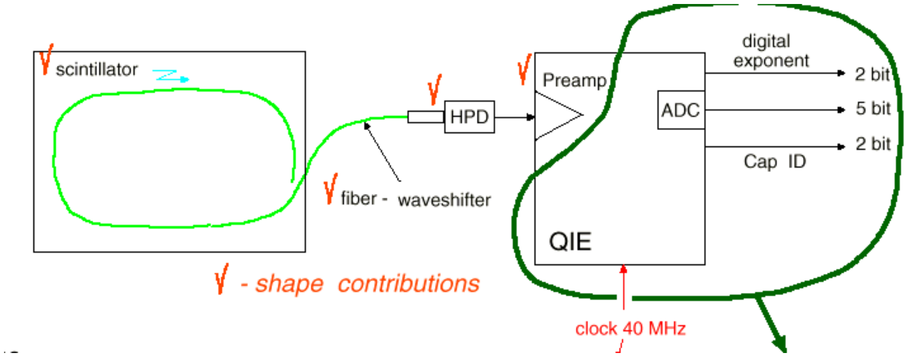
(S.Nikitenko)

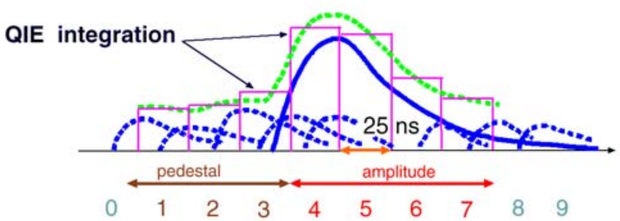
Lower threshold is better!

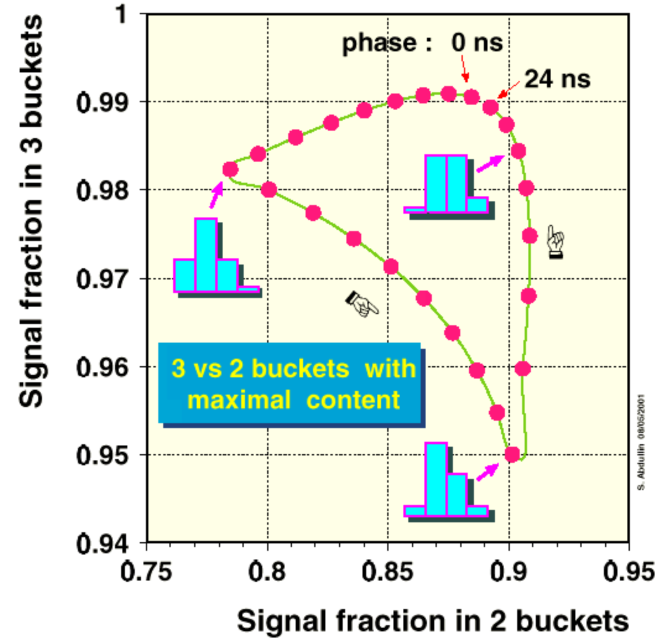
Electronics noise and occupancy define the threshold.
>> aim at 0.5GeV/tower @ 10E34

Front end electronics simulation

(S.Abdoullin)







(Original scheme)

E = Σ (Signal buckets)$_i$ – Σ(pre buckets)$_j$/n

Electronics noise 200MeV/25nsec/ch → 500MeV/(3+3) buckets/ch

→ New scheme: 2 buckets for signal
separate pedestal events

What's next for HLT?

Production

- **Complete CMS120 production**
  - Fall 2000 production for 2x10E33
    - **ooDigi – done // Ntuple – done this week, hopefully.**
  - Spring production for 2x10E33
    - **In progress.**
  - Production for 10E34 with new front end elec. simu.
- **Prepare for next production**

HLT rates calculation / Trigger table.

More Improvement …

- **Jets / MET**
  - Algorithm for better resolution and energy scale.
- **MET**
  - Algorithm to remove badly measured jet events.

→ Algorithm for 10E34!

Expanding group

We try to attract more people in the HCAL community and help them to get familiar with the CMS detector, CMS software and physics (analysis) at the LHC.

Assumption:

- geographical spread and diversity in skill level continue.

Strategy:

- lower the threshold for entering software development and data analysis.
- build a core software team for strong support (preferably in US).
- recruit experienced people to coordinate larger number of people.

Potential manpower:

- Universities in US, RDMS (not only ITEP and MSU), India, Turkey, Hungary…
- US CMS Software and Computing Project (Tier1 & CAS)

→ Started distributing hard disks with full CMS SW and MC events.
→ Regional meetings (Moscow, India, US)

Summary

Simulation

- Verify Simulation
- Transition to OSCAR/GEANT4

Calibration & Monitoring

- Scenario from construction to in-situ calibration.
- Improvement for energy scale and resolution.

HCAL Code in ORCA

- Readout simulation

HLT

- CMS120 data finally ready
  → rate calculation and trigger table (2xE33)
- Apply improved algorithm.
- Algorithm for E34.

Additional Slides

Algorithm for L1 through Offline (1)

L1 – calorimeter only (coarse segmentation)

- **Resolution improvement**
  - Equalize calorimeter response with simple correction
    - **a x EC + b x HC, a,b depends on jet(ET,h)**
    - **a x (EC+HC), a depends on jet(ET,h)**
- **Fake Jets/Pileup jets rejection**
  - Threshold cut on a central tower in jets (seed cut)

L2 – calorimeter only (fine segmentation)

- **Resolution improvement**
  - Better energy extraction from ADC counts
  - Em/had cluster separation using transverse shower shape in crystals
- **Fake jet/Pileup jet rejection**
  - Use of transverse shower shape

Algorithm for L1 through Offline (2)

L3 – calorimeter plus pixel

- **Resolution improvement**
  - Pileup energy subtraction
    - **Estimation of energy flow from pileup events using pixel hits/tracks.**
- **Fake jets/Pileup jets rejection**
    - **Vertex information and jet pointing using pixel hits/tracks.**

Offline – calorimeter plus fully reco-ed tracks

- **Resolution improvement**
- **Fake jets/Pileup jets rejection**
  - → Jet and MET will be reconstructed with Tracks, EM clusters and HAD clusters.
  - → All tracks down to E_T~ 700MeV have to be reconstructed at 10E34!
- **Physics correction – e.g. correction for IFR/FSR.**
  - → In-situ calibration!